CHEMICAL KINETICS

Introduction:

→ A chemical reactions involves the breaking of old bonds and formation of new bonds, In some reactions these processes occur very fast and in some other they occur slow. So the reactions are categorized as slow and fast reaction. For eg:- Neutralization reactions and ionic reactions are fast reaction while rusting is very slow rxn.

→ However there are some rxn which occur with measurable speed and their speeds (rates) can be measured in lab by means of suitable measurable property of the reaction like change in concn, volume, pressure, electrical conductivity, PH etc.

→ Following are some examples of chemical rxn's whose speed can be measured.

$$CH_3COOCH_3 + H_2O \longrightarrow CH_3COOH + CH_3OH$$

$$2N_2O_5 \longrightarrow 4NO_2 + O_2$$

$$2H_2O_2 \longrightarrow H_2O + O_2$$

→ Therefore, a branch of chemistry which deals with the rates of chemical reaction, factors affecting rate of chemical reaction and reaction mechanism is called chemical kinetics.

Rate of Reaction

- It tells how fast or slow is the reaction. In simple words it is the speed of reaction.
- It is defined as the change of concentration of either reactant or product per unit time.

$$\text{Rate} = \frac{\text{Change in concentration of reactant or Prod..}}{\text{Time required for change.}}$$

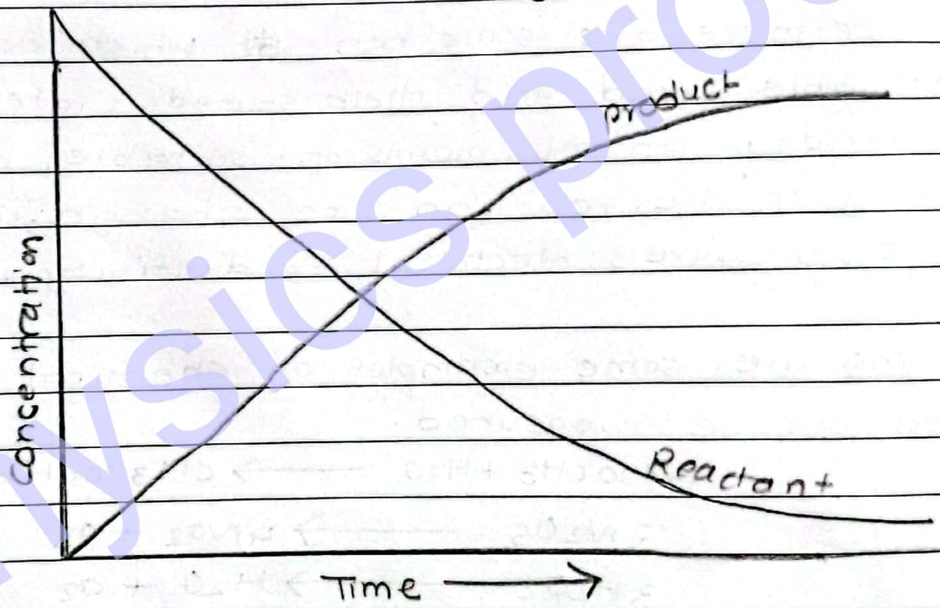


Fig: concentration change of reactants & products with time.

Average Rate of Reaction

- It is defined as rate of change of concentration of either reactant or product at particular interval of time.

Consider a general reaction,

$$A \longrightarrow B$$

For the given reaction we measure the concentration of A or B at time t1 and t2

time	[A]	[B]
t_1	A_1	B_1
t_2	A_2	B_2

→ The rate of rxn with respect of A and B are

Rate (A) $= \dfrac{[A_2] - [A_1]}{t_2 - t_1}$ Rate (B) $= \dfrac{[B_2] - [B_1]}{t_2 - t_1}$

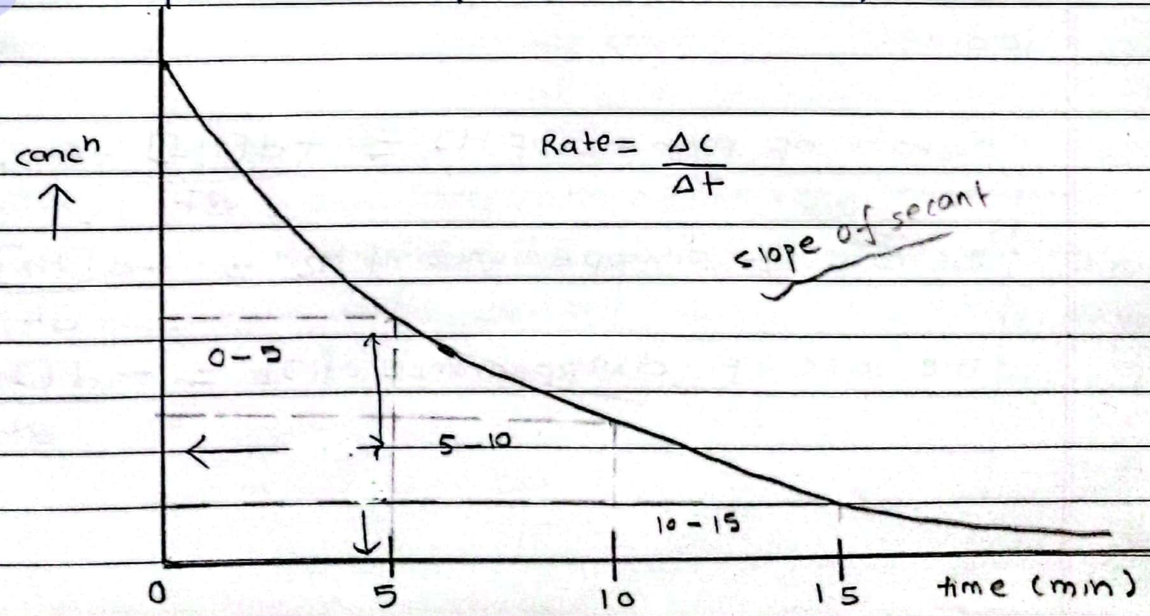
$= -\dfrac{\Delta A}{\Delta t}$ $(A_1 > A_2)$ $= \dfrac{\Delta B}{\Delta t}$ $(B_2 > B_1)$

→ The rate of reaction can't be negative, so –ve sign is introduced to make rate positive.

→ The –ve sign in Rate (A) indicates that the ~~[illegible]~~ conc^n of reactant is decreasing with time.

→ In rate (B), there is no –ve sign that means $B_2 > B_1$, which means conc^n of product is increasing

Graphical Representation of Average Rate of Rxn.



Instantaneous rate of reaction

→ It is defined as the rate of change of concentration of either reactant or product at particular instant of time.

→ Average rate of reaction becomes instantaneous when $t_2 \to t_1$ ie. $\Delta t \to 0$.

$$\therefore \text{Instaneous rate of rxn} = \lim_{\Delta t \to 0} (\text{average rate of rxn})$$

$$\text{or } \frac{dx}{dt} = -\lim_{\Delta t \to 0} \frac{\Delta[A]}{\Delta t} = +\lim_{\Delta t \to 0} \frac{\Delta[B]}{\Delta t}$$

$$= -\frac{d[A]}{dt} = +\frac{d[B]}{dt}$$

For General rxn, $A \to B$.

Rate of reaction and stoichiometric coefficient

$$H_2 + I_2 \longrightarrow 2HI$$

→ Here 1 mole of hydrogen reacts with one mole of iodine to for two moles of hydrogen iodide.

The rate of formation of HI $= +\frac{d[HI]}{dt}$

The rate of disappearance of H_2 $= -\frac{d[H_2]}{dt}$

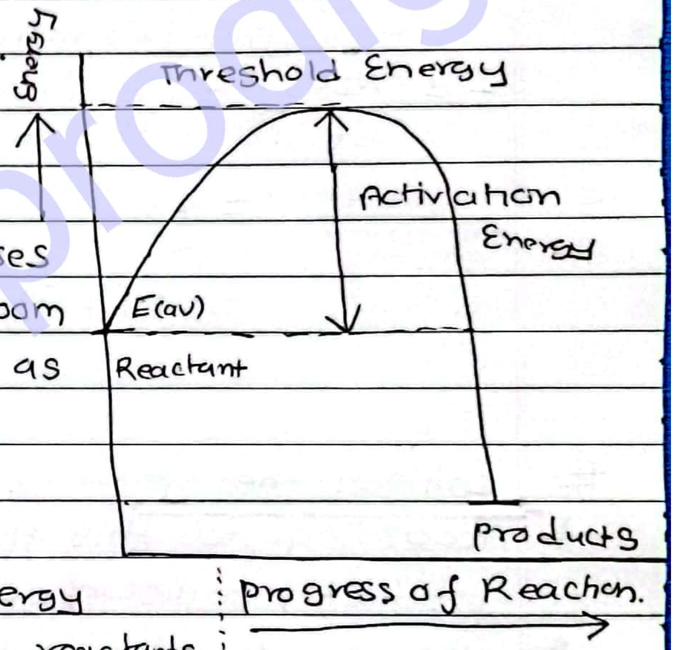
The rate of disappearance of I_2 $= -\frac{d[I_2]}{dt}$

$E_p > E_r$ → Absorption of Energy → Endothermic
$E_r > E_p$ → Releases Energy → Exothermic

Rate of Formation of HI = 2 × rate of disappearence of H_2
= 2 × rate of disappearence of I_2

$$\therefore \text{Equivalent Rate of rxn} = +\frac{1}{2}\frac{d[HI]}{dt} = -\frac{d[H_2]}{dt}$$
$$= -\frac{d[I_2]}{dt}.$$

Energy Terms :



1) Average Energy [E_{av}]

→ Every reacting molecules possesses a certain amount of Energy at room temperature which is known as average energy.

2) Activation Energy [E_a]

→ The minimum amount of Energy that must be associated with reactants to cross the energy barrier and form products is called Activation energy

3) Threshold Energy (E_{th})

→ It is the minimum amount of energy that must be associated with reactants to cross the energy barrier and form the product. It is the sum of average and activation energy.

$$\boxed{\text{i.e. } E_{th} = E_{av} + E_a}$$

Qn) In the rxn $2N_2O_5 \longrightarrow 4NO_2 + O_2$. If the rate of formation of NO_2 is 2×10^{-4} mol ltr^{-1} sec^{-1} Find the rate of formation of N_2O_5.

→ Solution:-

Rate of decomposition of N_2O_5

$$\text{Eq rate} = -\frac{1}{2}\frac{d(N_2O_5)}{dt} = \frac{1}{4}\frac{d[NO_2]}{dt} = \frac{d[O_2]}{dt}$$

Taking first two ratios

$$-\frac{d(N_2O_5)}{dt} = \frac{\cancel{2}}{\cancel{4}}\frac{d(NO_2)}{dt}$$

$$= \frac{1}{2}\times 2\times10^{-4}$$

$$= 1\times10^{-4}\ \text{mol ltr}^{-1}\ \text{sec}^{-1}$$

Taking last two ratios

$$\frac{d(O_2)}{dt} = \frac{1}{4}\frac{d(NO_2)}{dt}$$

$$= \frac{1}{4}\times2\times10^{-4}$$

$$= 5\times10^{-5}\ \text{mol ltr}^{-1}\ \text{sec}^{-1}$$

collison theory

→ According to this theory, for the formation of product, collision of the molecules is must.

→ Not every collision leads to the formation of product, only effective collision gives product.

→ For the collision to be effective the energy must be sufficient. so that they cross the imaginary energy barrier. and molecules must collide in proper orientation.

→ This theory assumes molecules as sphere.

→ This theory is applicable for bimolecular molecules only.

Remember Bio-collison ☺
te te.

Factors affecting Rate of reaction:

IMP

No. of collision per unit time is called collision frequency.

Rate of reaction $\propto$ collision frequency.

① Nature of reactant :- Ionic reactions are fast in nature whereas covalent reactions takes time as old bond need to break and new bond are formed.

② Concentration :- It is directly porpotional to ROR. As the $conc^n$ increases ROR increases and viceversa. When $conc^n$ increases; collision frequency increases and hence rate of rxn increases.

Qn) Why rate of rxn is more at beginning?

→ Because $conc^n$ is high at beginning -----

Qn) Why most of chemical's are available in powdered form?

→ For a given sample, powdered form has more surface area than that in lumbs and hence it helps to increase the Rate of reaction.

③ Surface Area :- It is directly porpotional to ROR. As the surface area increases, the chance of collision increases and then collision frequency increases which lead to increase the rate of rxn.

④ Tempeature :- It is directly porpotional to ROR. When tempeature increases, the K.E of the molecules also increases, then molecules vibrates fast

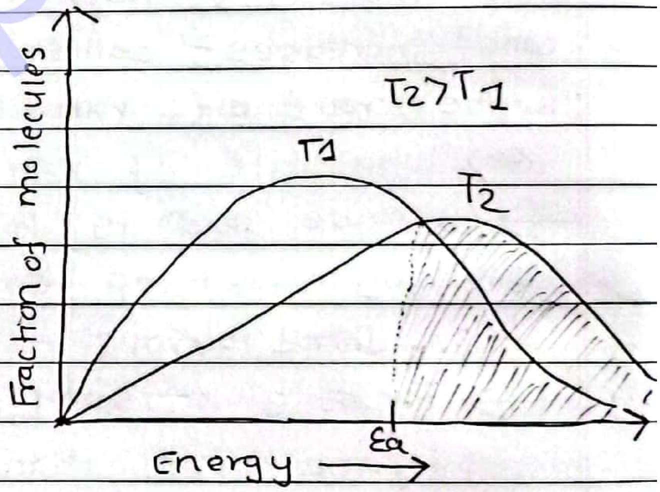
So chance of collision increases, then collision frequency increases and hence rate of reaction increases.

→ For each 10°c rise, ROR increases 2 or 3 times
2^n or 3^n

Above fact is explained by Tempeature coefficient
$(T\alpha) = \frac{K_{t+10}}{K_t} = 2$ or 3

Maxwell Energy Distribution curve.

→ It is the curve/graph plot btn. fraction of molecules to the energy associated with them. The graph shows at higher tempr. the fraction of collisions with sufficient energy equal to or greater than Ea increases, so ROR also increases.



Arrhenius Equation

→ Svante Arrhenius developed a mathmatical relationship between rate constant (K) and tempeature

$$\boxed{K = Ae^{-Ea/RT}}$$

A → frequency factor
Ea → Activation Energy
R → Universal gas constent.

$$\log k = \log A - \frac{Ea}{RT}$$

$$\boxed{\therefore k \propto T}$$

(T1 and T2)

For two different tempr, let k1 and k2 be their rate constant

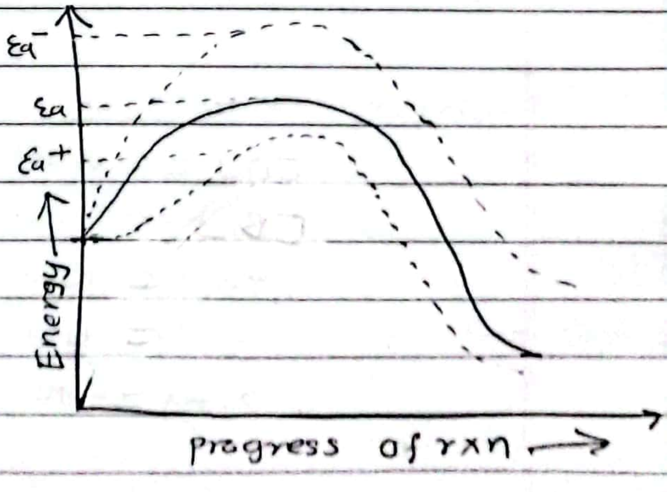
Then, $\log k_1 = \log A - \frac{Ea}{RT_1}$ $\quad \log k_2 = \log A - \frac{Ea}{RT_1}$

$$\log k_2 - \log k_1 = \log A - \frac{Ea}{RT_2} - \log A + \frac{Ea}{RT_2}$$

$$\log \left(\frac{k_2}{k_1}\right) = \frac{Ea}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right) = \frac{Ea}{R}\left(\frac{T_2 - T_1}{T_1 \cdot T_2}\right) \#$$

Catalyst. IMP

- A substance that alters the rate of reaction without undergoing any chemical change in itself is known as catalyst.
- There are two types of catalyst i> positive catalyst and ii> negative catalyst.
- Positive catalyst like MnO_2 increases the rate of rxn as it lowers the Activation energy and many more ~~more~~ molecules can cross the imaginary energy barrier.
- Negative catalyst like glycerol decreases the rate rate of rxn as they higher's the activation energy.



Here,
Ea = activation energy
Ea^+ = activation energy with +ve catalyst
Ea^- = activation energy with negative catalyst.

6) Light :- photochemical rxn's only takes place in presence of light. For such reactions,
Intensity of light $\propto$ ROR

Rate law VVIMP

- It explains the dependence of rate of rxn (ROR) on concn of species in reaction in which each concn term appears with certain power.
- This dependence is very complex as it changes with change in concn of species.
- Here, we only study the simplest form of dependence i.e. by conducting experiments.

Eg:- $2A + 3B \longrightarrow$ product.

If [A] double ROR $\rightarrow$ double

If [B] double ROR $\rightarrow$ 4 times

Then ROR $\propto [A]^1$ ROR $\propto [B]^2$

$\therefore$ ROR $= k[A]^1[B]^2$ #

In general term,

$$ROR = k[A]^x[B]^y$$

where k = rate constant

[A] = concn of A

[B] = concn of B

x = order of rxn w.r.t A [-ve, +ve, 0, frac]

y = order of rxn w.r.t B

x+y = overall order of rxn (n)

Rate Constant / Velocity constant / specific rxn rate (K)

we have,

$$RoR = k\,[A]^x\,[B]^y$$

IF $[A] = [B] = 1$ (unity) $mol\,Ltr^{-1}$ Then

$$RoR = k.$$

Thus rate constant is defined as the rate of rxn when the concentration of all the reactants is taken unity.

unit of Rate constant (K)

we have $RoR = k\,[A]^x\,[B]^y$

$$k = \frac{RoR}{[A]^x\,[B]^y} \quad \text{———} \; ①$$

$$\text{or } k = \frac{mol\,L^{-1}\,sec^{-1}}{(mol\,L^{-1})^x\,(mol\,L^{-1})^y}$$

$$\text{or } k = \frac{mol\,L^{-1}\,sec^{-1}}{(mol\,L^{-1})^{x+y}} \qquad (x+y=n)$$

$$\text{or } k = (mol\,L^{-1})^{1-n}\,sec^{-1}$$

Characterstics of Rate constant.

- It is specific to the rxn.
- It is dependent on tempeature.
- It is independent of concn as the ratio of ① alwa always remains constant.
- It measures Rate of Rxn (RoR)
- It's unit is dependent on order of rxn.
- Different rxn have diffrent values of rate const. So it is specific to the rxn.

unit of $k = (\text{mole } L^{-1})^{1-n}\ \sec^{-1}$

order of rxn (n)	units of k
0 (zero order rxn)	mole L^{-1} $\sec^{-1}$
1 (First " ")	$\sec^{-1}$
2 (second " ")	mole^{-1} L $\sec^{-1}$

and so on.

Qn) For $2A+B \longrightarrow$ products
when [A] is doubled alone, RoR increased by 2
when [A] & [B] both are doubled RoR increase by 8 times. write rate law expression. Find order of rxn.

⇒ we have,

$$RoR = k[A]^x [B]^y$$

$x=1$ ([A] double, RoR double]

$$2\,RoR = k[2A]^x[B]^y \quad —— ①$$

$(x=1)$

When both doubled,

$$8RoR = k[2A]^1\ [2B]^y$$

$$8RoR = 2k[A]^x \cdot [2B]^y \quad —— ②$$

when ② ÷ ① we get

$$4 = \frac{[2B]^y}{[B]^y} = 2^y$$

$$2^y = 4 = (2)^2$$

$$\therefore y = 2.$$

So rate law expression is,

$$RoR(r) = k[A]^1\ [B]^2 \quad \#$$

Order of rxn $= x+y = 1+2 = 3$
3rd order of rxn.

RoR $\propto$ K.

Q7) $A + 2B + 4C \longrightarrow$ product

when volume of cointainer is doubled, RoR decreases 8 times. when $[A] \rightarrow$ doubled $[B] \rightarrow$ halfed, RoR Increases 4 times

When $[C]$ Increases 4 times RoR increases 64 times

Find rate law expression and order of reaction.

→ when voln of cointainer is doubled

$[A] = \left[\frac{A}{2}\right]$ $[B] = \left[\frac{B}{2}\right]$ $[C] = \left[\frac{C}{2}\right]$.

General term, $RoR = k\,[A]^x [B]^y [C]^z$. — ①

$\frac{1}{8} RoR = k \left[\frac{A}{2}\right]^x \left[\frac{B}{2}\right]^y \left[\frac{C}{2}\right]^z$ ②

①÷② we get $8 = 2^x \cdot 2^y \cdot 2^z = 2^{(x+y+z)}$

$x+y+z = 3$ — ③

case 2>>

$4\,RoR = k[2A]^x\, [\overset{1}{2}B]^y\, [C]^z$ — ④

Dividing ④ by ① we get

$4 = 2^x \cdot 2^y \cdot = 2^{(x+y)}$

$x - y = 2$. — ⑤

From ③ and ④ we get,

~~$z = 3 - 2 = 1$~~ ✗

case 3>>

$64\,RoR = k\,[A]^x [B]^y [4C]^z$. — ⑥

Dividing ⑥ by ① we get

$64 = 4^z$. $\Rightarrow [4]^3 = [4]^z$

$\therefore z = 3$ ✓

$x+y+z=3$

$x+y+3=3$

$x+y=0$ ✱

$x-y=2$ ✱

$2x = 2 \Rightarrow x = 1$

$y = 3 - x - z$

$= 3 - 1 - 3 = -1$

so required rate expression is

$$RoR(r) = k[A]^1 [B]^{-1} [C]^3$$

$$\text{order of rxn} = x+y+z$$

$$= 1-1+3 = 3$$

third order of rxn

Some important points about order of Rxn.

<1> Stochiometric coefficients have nothing to do with order of rxn.

$$2N_2O_5 \longrightarrow 4NO_2 + O_2$$

$$RoR = k[N_2O_5]^1$$

Experimental

<2> In rate law, concentration terms of products can be present.

$$2O_3 \longrightarrow 3O_2 \quad RoR = k[O_3]^2 [O_2]^{-1}$$

↳ product

<3> In rate law, concentration term of some ____ catalyst may be present

$$2SO_2 + O_2 \xrightarrow{NO} 2SO_3$$

$$RoR = k[O_2]^2 [NO]^1$$

↳ catalyst

(4) In rate law, concn term of some reactant may be absent

$$NO_2 + CO \longrightarrow NO + CO_2$$

$$RoR = k[NO_2]^2 [CO]^0$$

$$Ror = k[NO_2]^2$$

Simple/ Elementary single Step Reaction.

→ law of mass action may be valid in some rxn

$$2x + 3y \longrightarrow 4z$$

$$ROR = K[x]^2 [y]^3$$

If and only if rxn is simple and single step

Eg:-

$$H_2 + I_2 \longrightarrow 2HI \quad \text{(simple)}$$

$$\text{Then} \quad ROR = K[H_2]^1 [I_2]^1$$ ✗

(Guldberg & wugge law of mass action)

Rate of reaction	Rate constant of reaction
- It is the change in the concentration of either reactants or product.	- It is the porportionality constant of rate law expression.
- It depends on concentration of reactants	- It doesnot depend on concentration of reactants
- It decrease with progress of time.	- It remains constant and is independent of the progress of the rxn.

Order of Reaction

Let us consider a general reaction

$$aA + bB \longrightarrow cC + dD$$

Then rate law of the reaction is

$$Rate = K[A]^x [B]^Y$$

where x and Y are constant numbers. They are known as the order of reaction with respect to A and B respectively. Then the overall order of reaction is $m+n$.

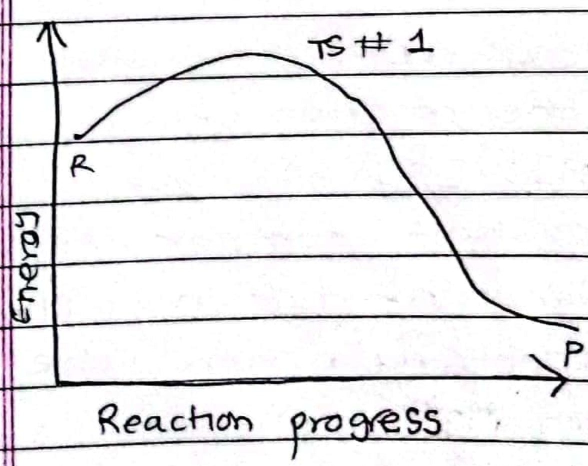
→ Thus, the order of reaction is defined as the sum of all the power of the concentration terms in the rate equation.

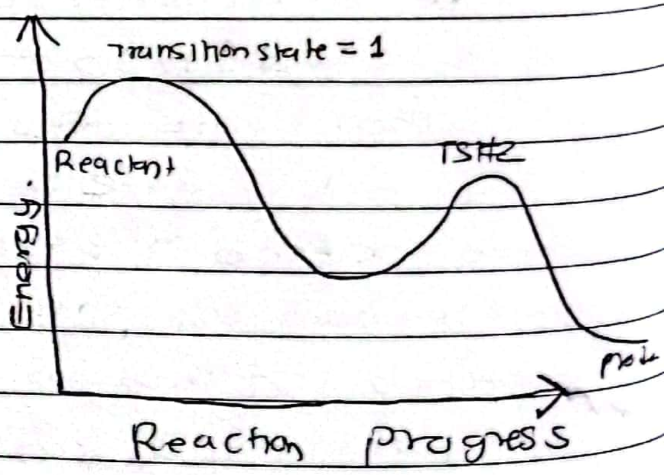
→ It indicates the degree in which the rate depends on the concentration of that particular reactant.

Molecularity of Reaction :

→ Reactions can be divided on the basis of reaction mechanism

Elementary / simple Rxn	Complex Reactions
• only one step reactions	• Two or more steps with different speed.
• No intermediate	• With intermediate Formation.
• Only one transition state	• Multiple transition state
• Further divided into unimolecular, Biomoleculor & Ter molecular rxn based on molecularity.	• Rate of overall complex rxn is the rate of slowest rxn step (Rate determining step, RDS)





Total no. of reacting species which collide simultaneously to bring produt is called molecularity.

For elementary or simple reaction

→ Reaction completes in only one step.

→ It can be determined from the sum of stoichiometric coefficient of the balanced chemical equation.

→ molecularity and order of rxn are same for the simple reaction. Here unimolecular rxn is first order and bimolecular rxn is second order and so on.

For complex reaction

→ Reaction completes in more than one step.

→ Each step is elementary reaction. The overall reaction is obtained by adding all the elementary steps.

→ These elementary steps give the detail description about the reaction. So they are called mechanism of the reaction.

→ These various elementary steps have different rates. Some of the steps are fast and some are slow.

→ The overall rate of the reaction is determined by the step whose rate is the slowest. Therefore, the slowest reaction is known as rate determining step (RDS).

→ Molecularity of the complex reaction is determined from the number of reacting species ~~having~~ involving in the rate determining step. For complex reaction, the number of reacting species present in the rate determining step is the molecularity of the complex reaction.

$$2N_2O_5 \longrightarrow 4NO_2 + O_2 .$$

$H_2 + Cl_2 \rightarrow 2HCl$

$R = dx/dt = k[H_2]^0[Cl_2]^0 = k$ $\Bigg\{$ $NH_3 \rightarrow N_2 + 3H_2$

$R = k[NH_3]^0 = k$

zero-order reaction :

IMP

→ In zero order rxn, the rate of reaction is independent of concentration of reactants

Let us consider general zero-order reaction

$A \rightarrow$ products.

The rate law for this is

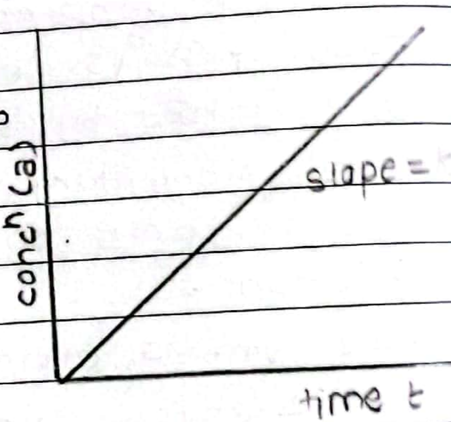
Rate $= k[A]^0$

Then, $\frac{d[A]}{dt} = k_0$ {differential rate eqn}

$x = kt$

$y = mx + c$

Let	A	→	products
Initially	a mol L^{-1}		0
After time t	$(a-x)$		x.



Then, $\frac{dx}{dt} = k_0 \cdot (a-x)^0$

$dx = k_0 dt$

on integrating

$\int dx = \int k_0 dt$

$x = k_0(t) + I$

where I is integrating constant

when $t = 0$, $x = 0$.

$\therefore I = 0$

So, $x = k_0 t$

$\boxed{k_0 = \frac{x}{t}}$ } integrated rate eqn of zero order rxn

$x = kt$

Half life

$t = t_{1/2}$, $x = a/2$

$k_0 = \frac{a/2}{T_{1/2}}$.

$\boxed{T_{1/2} = \frac{a}{2k_0}}$ → $\boxed{T_{1/2} \propto a}$

ALL decomposition rxn are 1st order rxn

First order rxn

* Rate depends on ~~only~~ first power of conc^n terms. or only one conc^n terms.

	A $\longrightarrow$	Products
Initial	a	0
Final (t)	$(a-x)$	x

$R \propto A^1$ (for first order)

$R = k A^1$

$\frac{dx}{dt} = k(a-x)$. [Diffrential rate eqn]

$$\frac{dx}{(a-x)} = k\,dt$$

on integrating we get

$$-\ln(a-x) = k_1 t + I \quad \text{——} ①$$

where I is integrating constant.

Initially $x=0$ and $t=0$.

so, $-\ln(a) = I$. so eqn ① becomes.

$$-\ln(a-x) = k_1 t - \ln a.$$

$$k_1 t = -\ln(a-x) + \ln a.$$

$$k_1 t = \ln\left(\frac{a}{a-x}\right)$$

$$k_1 = \frac{2.303}{t}\log\left(\frac{a}{a-x}\right) \quad [\because \ln = 2.303 \log]$$

[Integrated rate eqn]

Half life

$= a/2 \qquad t = T_{1/2}$.

$$k_1 = \frac{2.303}{T_{1/2}}\log\left(\frac{a}{a-a/2}\right)$$

$$T_{1/2} = \frac{2.303}{k_1}\log\left(\frac{2a}{a}\right)$$

$$T_{1/2} = \frac{0.693}{k_1}$$

Graphical Representation of first order rxn.

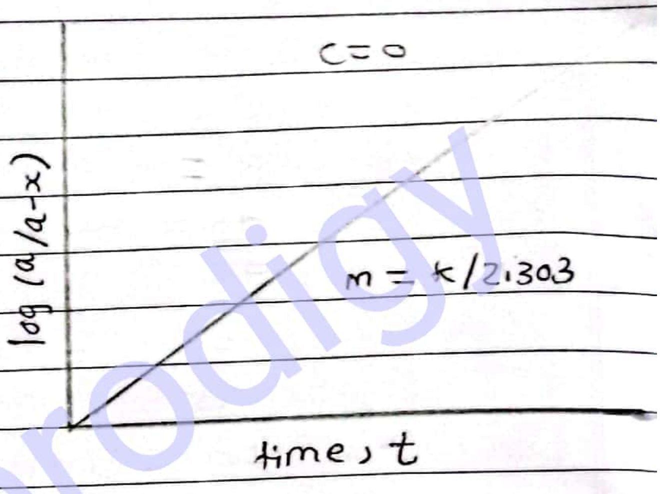
Integrated eqn is,

$$kt = 2.303 \log\left(\frac{a}{a-x}\right)$$

Rearranging eqn

$$\log\left(\frac{a}{a-x}\right) = \frac{k}{2.303} t$$

$$y = mx + c.$$



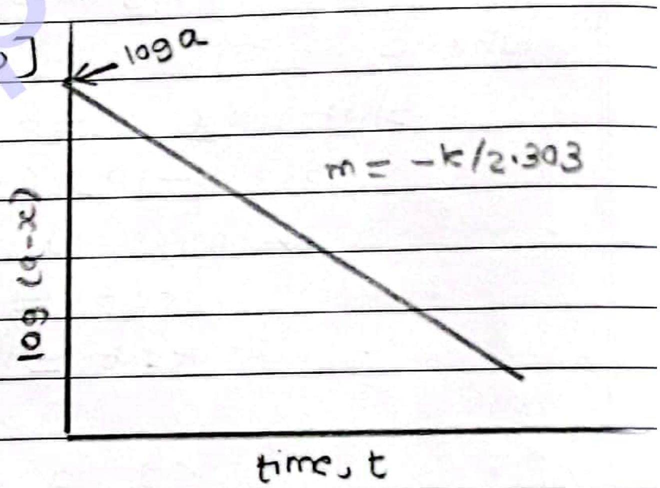
Also,

$$kt = 2.303 [\log a - \log (a-x)]$$

$$\frac{k}{2.303} t = [\log a - \log (a-x)]$$

$$\log (a-x) = \frac{-k}{2.303} t + \log a$$

$$y = mx + c$$



Second-order reaction.

→ The rxn whose rate is determined by change of two concn terms (m+n=2) is called the second order rxn.

$$\text{Rate} = \frac{dx}{dt} = k[A]^2 \;/\; k[A][B]$$

$$H_2 + I_2 \longrightarrow 2HI$$

$$3NO \longrightarrow N_2O + NO_2$$

Third order Rxn

→ The rxn which is dependent in three concn terms.

$$R = \frac{dx}{dt} = k[A]^3 \ / \ k[A][B][C] \ / \ k[A]^2$$

$2NO + O_2 \rightarrow 2NO_2$ $R = k[NO]^2[O_2]$

$2NO + Cl_2 \rightarrow 2NOCl$ $R = k[NO]^2[Cl_2]$

Pseudo ORder Rxn

→ Higher order reaction which follows lower order kinetics is called pseudo order rxn.

→ If higher order rxn follows first order kinetics then rxn is called pseudo-first order rxn.

→ When one of the reacting species is present in large access in the reaction. The ROR is independent of concn of the species.

Let us consider hydrolysis rxn of cane sugar.

$C_{12}H_{22}O_{11} + H_2O \rightarrow C_6H_{12}O_6$ (glucose) $+ C_6H_{12}O_6$ (fructose)

Rate law order rxn is

$$\text{rate} = k[C_{12}H_{22}O_{11}][H_2O]$$

This rxn seem to follow 2nd order but if large access of water is taken then amount of

$k =$

9n) A First order rxn has rate constant 1.3×10^{-3} per sec. How long does this rxn take to finish 60% of the rxn?

→ Let the First order rxn be,

$$A \longrightarrow \text{Product}$$

$t = 0$ $\qquad a = 100\%$ $\qquad x = 0$

$t = ?$ $\qquad (a-x) = (100-60)\%$ $\qquad x = 60\%$.

$= 40\%$.

For first order rxn:

$$k = \frac{2.303}{t} \log\left(\frac{a}{a-x}\right)$$

$$1.3 \times 10^{-3} = \frac{2.303}{t} \log\left(\frac{100}{40}\right)$$

$$\therefore t =$$

② A rxn has rate constant 0.005 per minute. How long does it take to complete 90% of the rxn?

→ Here, the rate constant is 0.005 per min so ~~Here~~ it is First order rxn.

For First order rxn, completes in infinite time.

⑤ A First order rxn has half life period 30 minute. How long does this rxn does this rxn take to Finish 87.5% of the rxn?

→ Here, $T_{1/2} = 30$ min,

Now, rate constant $(\lambda) = \frac{0.693}{T_{1/2}}$

$= \frac{0.693}{30\ \text{min}}$

$= 0.0231$ per min.

Let the First order rxn be,

$A \longrightarrow$ product

$t=0$ $\quad a = 100\%$ $\quad x = 0$

$t = ?$ $\quad (a-x) = 100-87.5\%$ $\quad x = 87.5\%$

$= 12.5\%$

Now we have

$$k = \frac{2.303}{t} \log\left(\frac{a}{a-x}\right)$$

$$0.0231 = \frac{2.303}{t} \log\left(\frac{100}{12.5}\right)$$

$t = 90$ minutes. ans

④ A First order rxn takes 20 min to complete 80% of the rxn. How long does the same rxn takes to complete 95%. Of the rxn.

→ Let the first order rxn be, $\quad$ case II

$A \longrightarrow$ product $\qquad$ $A \rightarrow$ product

$t=0$ $\quad a$ $\quad 0$ $\qquad$ 100% $\quad 0$

$t=20$min $\quad 20\%$ $\quad 80\%$ $\qquad$ 5% $\quad 95\%$

Now $k = \frac{2.303}{t} \log\left(\frac{a}{a-x}\right)$ $\qquad$ $t = \frac{2.303}{0.011} \log\left(100/5\right)$

$= 2.303/20 \log\left(100/20\right) = 0.011$ per min. $\qquad$ $= 268$ min.

$(\text{mol L}^{-1})^{1-n}\ \text{sec}^{-1}$

⑤ A first order rxn has rate constant 0.03 per sec. If the initial conc^n of reactant is 2 mol per ltr. How long does it take to form 0.75 mol Ltr^{-1} of product.

→ Here, $k = 0.03$ per sec

$a = 2 \text{ mol ltr}^{-1}$ $\quad x = 0.75 \text{ mol ltr}^{-1}$

$a - x = (2 - 0.75) = 1.25 \text{ mol ltr}^{-1}$

Now, $t = \frac{2.303}{k} \log\left(\frac{a}{a-x}\right)$

$= \frac{2.303}{0.03} \log\left(\frac{2}{1.25}\right) = 15.66$ per sec.

⑥ $Cl_2 + 2NO \longrightarrow 2NOCl$

Exp. NO.	$[Cl_2]$	Initial rate
1	0.02	2.4×10^{-4}
2	0.02	2.16×10^{-3}
3	0.04	4.32×10^{-3}.

Determine:-

i) order of rxn w.r.t to Cl_2 and NO and overall

ii) If $[Cl_2] = 0.5 \text{ mol L}^{-1}$ & $[NO] = 0.4 \text{ mol L}^{-1}$ what is rate?

→ Let the rate law eqn be:

$$\text{Rate} = k\,[Cl_2]^m\,[NO]^n \quad \text{——— ①}$$

From given data

$$2.4 \times 10^{-4} = k\,[0.02]^m\,[0.02]^n \quad \text{——— ②}$$

$$2.16 \times 10^{-3} = k\,[0.02]^m\,[0.03]^n \quad \text{——— ③}$$

$$4.32 \times 10^{-3} = k\,[0.04]^m\,[0.03]^n \quad \text{——— ④}$$

$(mol\,L^{-1})^{1-3}\ sec^{-1}$

$mol^{-2}\,L^{2}\,sec^{-1}$.

Dividing ⓘⓘ by ⓘⓘⓘ we get.

$$\frac{2.4\times10^{-4}}{2.16\times10^{-3}} = \frac{(0.01)^n}{(0.03)^n}$$

or $\frac{1}{9} = \left(\frac{1}{3}\right)^n$. ⇒ $\left(\frac{1}{3}\right)^2 = \left(\frac{1}{3}\right)^n$.

∴ $n = 2$

Dividing ⓘⓘⓘ by ⓘⓥ we get

$$\frac{2.16\times10^{-3}}{4.32\times10^{-3}} = \frac{(0.02)^m}{(0.04)^m}.$$

$\frac{1}{2} = \left(\frac{1}{2}\right)^m$ ⇒ ∴ $m = 1$

Hence the order of rxn w.r.t Cl_2 is 1st and w.r.t NO is 2nd. And overall is 3rd.

Putting the value of m and n in eqn ① we get

$2.4\times10^{-4} = k\,[0.02]^1 . [0.02]^2$.

∴ $k = \frac{2.4\times10^{-4}}{8\times10^{-6}} = 30 .\ mol^{-2}L^{2}sec^{-1}$

If $[Cl_2] = 0.5$ and $[NO] = 0.4\ mol\,L^{-1}$

Then Rate $= k\,[Cl_2]^m\,[NO]^n$

$= 30\,[0.5]^1\,[0.4]^2$

$= 2.4$ mol/sec.

Q2) The following rate data are obtained at 303 K for the reaction

$$2A + B \longrightarrow C + D$$

EXP	[A] mol L⁻¹	[B] mol L⁻¹	Initial rate of formation of [D] in mol L⁻¹
1	0.1	0.1	6×10^{-3}
2	0.3	0.2	7.2×10^{-2}
3	0.3	0.4	2.88×10^{-1}
4	0.4	0.1	2.4×10^{-2}

Find order of rxn and value of k.

→

Let the rate law equal be

$$\text{Rate} = k\ [A]^x\ [B]^y \text{ ——— } ①$$

From given data,

$$6\times10^{-3} = k\ [0.1]^x\ [0.1]^y \text{ ——— } ②$$

$$7.2\times10^{-2} = k\ [0.3]^x\ [0.2]^y \text{ ——— } ③$$

$$2.88\times10^{-1} = k\ [0.3]^x\ [0.4]^y \text{ ——— } ④$$

$$2.4\times10^{-2} = k\ [0.4]^x\ [0.1]^y \text{ ——— } ⑤$$

Dividing eqn ③ by ④ we get,

$$\frac{7.2\times10^{-2}}{2.88\times10^{-1}} = \left(\frac{0.2}{0.4}\right)^y$$

$$\frac{1}{4} = \left(\frac{1}{2}\right)^y \Rightarrow \left(\frac{1}{2}\right)^y = \left(\frac{1}{2}\right)^2$$

$$\therefore y = 2 \checkmark$$

Dividing eqn ② by ⑤ we get

$$\frac{6\times10^{-3}}{2.4\times10^{-2}} = \left(\frac{0.1}{0.4}\right)^x \Rightarrow x = 1 \checkmark$$

∴ order with respect to A is 1 and B is 2.

overall order = $x+y$ = 1+2 = 3

∴ rxn is of 3rd order,

putting value of x and y we get, in eqn ①

$6\times10^{-3} = k\,[0.1]^1 \cdot [0.1]^2$

∴ k = 6 Lt

e) What will be the initial rate of rxn if it's rate constant is 1×10^{-3} min^{-1} and the conc^n of reactant is 2mol L^{-1}? How much the reactant will be converted into product in 500 min?

→ Given, Let rxn be A ⟶ Product,

Rate constant (k) = 1×10^{-3} min^{-1}

since unit of k is in min^{-1} so the order of rxn is 1st order.

conc^n of reactant [n] = 0.2 mol L^{-1}

$T_{1/2} = \dfrac{0.693}{k}$

=

we know first First order rxn,

$R = k\,[n]^1$

$= 1\times10^{-3} \times (0.2)$

$= 2\times10^{-4}$ mol L^{-1} min^{-1} .#

Now, we have

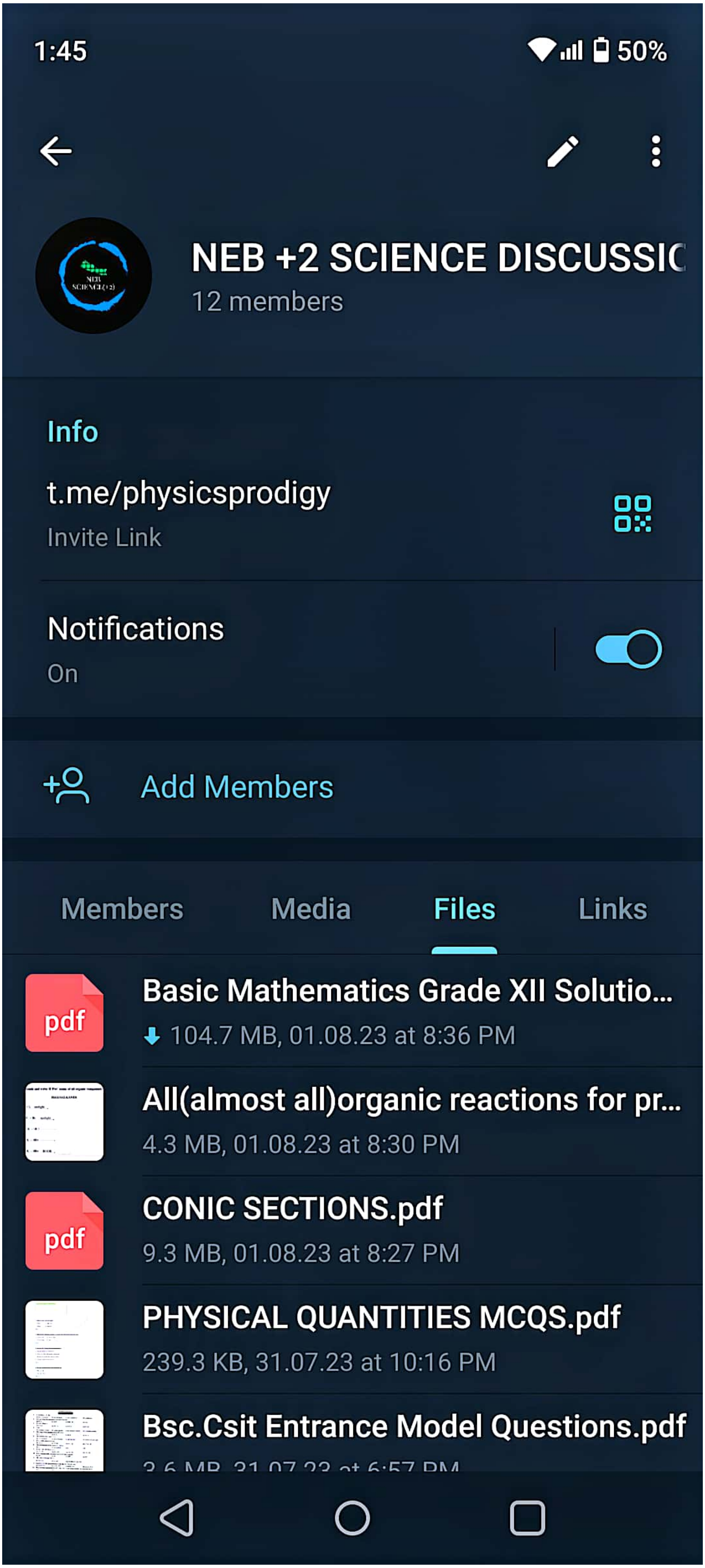
A ⟶	Product
a (0.2).	0
a−x	x.
(0.2−x).	

$$k = \frac{2.303}{t}\log\left(\frac{a}{a-x}\right)$$

$$1\times10^{-3}\cdot = \frac{2.303}{500}\log\left(\frac{0.2}{0.2-x}\right)$$

∴ $x = 0.0782$ mol L^{-1}

NEB
SCIENCE(+2)



NEB +2 SCIENCE DISCUSSIC

12 members

Info

t.me/physicsprodigy

Invite Link

Notifications

On

Basic Mathematics Grade XII Solutio...

104.7 MB, 01.08.23 at 8:36 PM

All(almost all)organic reactions for pr...

4.3 MB, 01.08.23 at 8:30 PM

CONIC SECTIONS.pdf

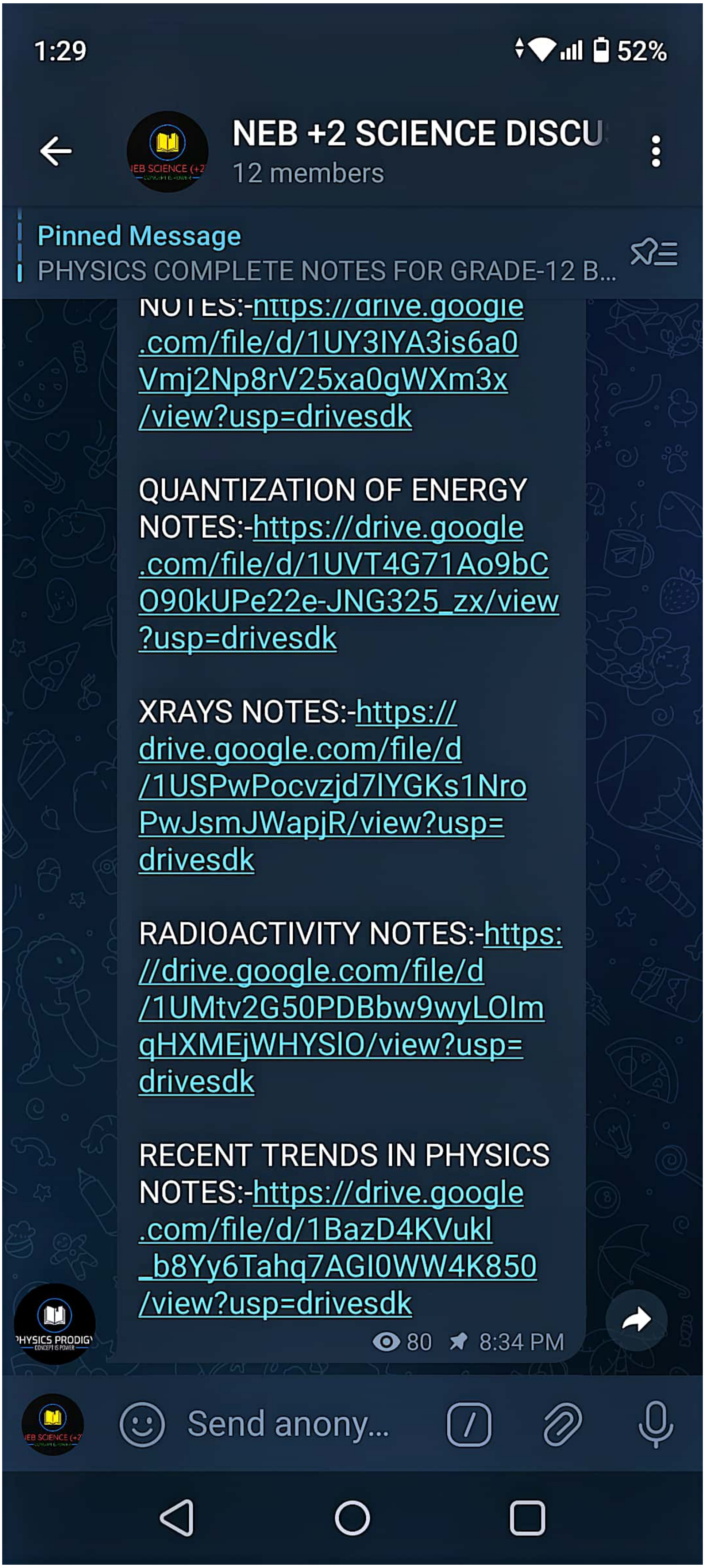
9.3 MB, 01.08.23 at 8:27 PM

PHYSICAL QUANTITIES MCQS.pdf

239.3 KB, 31.07.23 at 10:16 PM

Bsc.Csit Entrance Model Questions.pdf

3.6 MB, 31.07.23 at 6:57 PM



NOTES:-https://drive.google.com/file/d/1UY3IYA3is6a0Vmj2Np8rV25xa0gWXm3x/view?usp=drivesdk

QUANTIZATION OF ENERGY NOTES:-https://drive.google.com/file/d/1UVT4G71Ao9bCO90kUPe22e-JNG325_zx/view?usp=drivesdk

XRAYS NOTES:-https://drive.google.com/file/d/1USPwPocvzjd7lYGKs1NroPwJsmJWapjR/view?usp=drivesdk

RADIOACTIVITY NOTES:-https://drive.google.com/file/d/1UMtv2G50PDBbw9wyLOImqHXMEjWHYSlO/view?usp=drivesdk

RECENT TRENDS IN PHYSICS NOTES:-https://drive.google.com/file/d/1BazD4KVukl_b8Yy6Tahq7AGI0WW4K850/view?usp=drivesdk

80 8:34 PM